

Growth Performance of Intercropping System Components and Nutrient Status of Soil under Horti-silvicultural System

W.S. Dhillon¹, S.K. Chauhan², N. Jabeen¹, C. Singh¹ and N. Singh¹

¹Department of Horticulture,

²Department of Forestry and Natural Resources, Punjab Agricultural University, Ludhiana-141 004, India
 Email:chauhanpau@rediffmail.com

(Abstract) Poplar clone, a short rotation timber specie, was included as timber tree and guava (*Psidium guajava* L.), kinnow (*Citrus reticulata*), pear (*Pyrus communis* L.), peach (*Prunus persica* (L.) Batsch) and plum (*Prunus Americana* Marsh) as horticultural components to evaluate growth performance and nutrient status under horti-silvicultural system in irrigated agroecosystem. Growth increment of poplar was significantly higher when planted with fruit crops as compared to sole poplar planting. Availability of macro-nutrients (N, P, K) and organic carbon was determined at different depths of soil and a decrease in availability of nutrients with increasing depth was recorded. The release of nutrients from decomposition of litter-fall was less during winter because of low temperature, but increase of ambient temperature in June-August increased their availability. The macro-nutrients tended to increase with time due to higher inputs of organic matter. Out of different planting patterns viz. poplars as filler, windbreak, available phosphorus and nitrogen were found on higher side in an another experiment where poplar was used as filler tree.

Keywords: Poplar; Fruit Plants; Intercropping; Growth; Nutrients; Horti-silvicultural System.

1. INTRODUCTION

Diversification of existing farming systems by developing suitable agroforestry models seems to be the need of the day to cope-up with ever increasing demand for diversified products such as food, fiber, fodder, fruit, timber, etc. The existing land use systems with separate allocation to agriculture, horticulture and forest are inadequate to meet these demands. Agroforestry (growing trees + crops) provides a viable option to these systems with opportunities to diversify as well as increase overall land productivity and nutritional security. In Punjab (India), horticulture is being appreciated by the farming community due to many advantages such as nutritional security, economic prospects and above all, less labour intensive operations, etc. However, to make use of fruit tree inter-plant spacing and generate more income during the juvenile stage of fruit plants, fast growing timber trees are encouraged in the system. Chandra[1] emphasized that poplar's attributes such as ease of propagation through cuttings, easy establishment, rapid growth, straight cylindrical bole, deciduous nature and high volume returns make this species suitable for cultivation under agroforestry systems. Karnatak[2] emphasized that poplar can be grown on a short rotation of 5–7 years and the farmers need not to wait for

long for realizing the returns and they can make use of inter-space of fruit plants judiciously for economic gains. Besides, poplar trees are characterized by higher rates of nutrient accumulation in soils through litter fall as compared to other deciduous tree species. Bernier[3] recorded that poplars are efficient in the cycling of nutrients and a large portion of nutrients utilized for annual growth are periodically involved in cycling. The leaf fall contribute to the addition of organic matter as well as nutrients to soil. Tree plantations improve soil physical, chemical and biological properties through accretion and decomposition of organic matter through litter-fall and roots. During the life of a tree crop, large quantities of nutrients returned to the soil by the ground litter, harvest residues, stem flow and through-fall have been reported by Mohsin, Singh and Singh[4]. Deep and extensive root systems of trees enable them to absorb substantial quantities of nutrients below the rooting zone of crops and transfer them to surface soil has been referred by Allen et al[5]. Mugendi and Nair[6] has reported that the decomposition and release of nutrients from organic matter is a function of biomass quality, soil conditions and climate. The present study aims to evaluate the growth interaction of poplar and fruit trees, organic matter addition and macro-nutrient status of soil under different planting pattern in horti-silvicultural system for ecological stability of irrigated agro-ecosystem.

2. MATERIALS AND METHODS

The study was conducted in the experimental area of Department of Horticulture, Punjab Agricultural University, Ludhiana (India) located at 30° 45' N latitude and 75° 18' E longitudes at an elevation of 247 m above mean sea level. The climate of the experimental area is sub-tropical to tropical with dry season from late September to early June and wet from July to September. The area receives annual rainfall of 704 mm. The soil is classified as sandy-loam illitic ustic Typic Calciorthent.

The layout was prepared to accommodate poplar plants between fruit plants to make use of vacant inter-unutilized spaces. Healthy stock of fruit plants viz, Peach cv. Shan-i-Punjab, Plum cv. Satluj Purple, Guava cv. Allahabad Safeda and Hybrid Mandarin (Kinnow) raised in the departmental nursery were planted at recommended spacing of 6 x 6 m in pits of 1m³ dimension. One year old poplar clone "G-48" ETPs (Entire Trans Plants) procured from WIMCO Seedlings Pvt. Ltd were planted in three different experimental models viz., Inter-cropping of poplar trees between fruit crops, Poplar trees as wind break/boundary plantation, Poplar and other fruit crops as filler with pear cv. Punjab Beauty as main fruit crop. The inter-row space was utilised in cultivation of fruit trees and agricultural crops. Control plots of each crop were also raised at adjacent space for comparison.



Figure 1. Leaf traps under poplar based system

Height of trees was recorded from base of the tree to growing tip with the help of Multimeter. Girth at breast height (GBH) was recorded with measuring tape at 1.37m above from ground level.

To assess the poplar leaf biomass input, randomly three to five quadrates comprising of 1m² and 2m² areas were laid in all the directions under the three ages of poplar trees (Fig. 1). The leaf litter was collected every fortnight starting from mid-October to mid-February. The collected litter was oven dried at 70±2°C for about 72 hrs and weighed. To know the rate of decomposition and nutrient addition by the poplar leaf fall, a separate replicated experiment was laid out. Leaf litter decomposition was studied using nylon mesh bag technique. Nylon netting bag of 2 mm mesh size were filled with 200 g dried leaves and buried under the soil.

Litter bags were placed randomly at two plots. The rate of decomposition was accessed for the period of 7 months starting from April to October. The residual litter was brought to the laboratory and analysed for chemical analysis. To access the availability of different nutrients at different depths, the soil samples were collected from different age poplar plantations with different planting geometries (poplar as wind break and filler tree) at five variable depths (upto 120cm) and the physio-chemical analysis was done in the laboratory for assessment of major elements and organic matter composition of the soil at variable depths. Systat-11 statistical software developed by Wilkinson and Coward[7] was used for computation of descriptive statistics (mean, standard deviation, correlation, Shaphiro Wilk's statistic for normality testing, etc.).

3. RESULTS AND DISCUSSION

3.1. Inter-cropping of fruit crops between poplar trees: growth attributes

The growth attributes of poplar trees were recorded from 10 days after planting to 56 months after planting. The maximum mean basal girth was recorded in poplar planted with kinnow (75.88 cm) followed by poplar planted with peach (69.78 cm), while lowest basal girth was recorded in control (53.90 cm). The maximum diameter at breast height was recorded in poplar trees inter-planted with guava (18.87 cm) followed by poplar inter-planting with kinnow (17.67 cm), which was at par when raised with peach (17.27 cm), whereas, lowest DBH was recorded in control (15.16 cm). Likewise maximum average height was observed in poplar inter-planting guava (10.11m) followed by kinnow (9.52 cm), whereas, the minimum height was observed in control (7.93 m). Overall poplar had its better growth when planted as intercrops, which may be attributed to the fact that management practices for fruit plants indirectly boosted poplar tree growth. Plantations receiving various silvicultural treatments of pruning, irrigation, fertilization and inter-cultivation have better growth and timber productivity than sole trees or poorly managed plantations. Similar observations were also recorded by Singh, Singh, Dagar, Singh and Sharma[8] and Chauhan and Singh[9]. The comparison of growth attributes of poplar in inter-cropping and control after 56 months of planting are shown in Fig. 2 and comparison of different treatments are shown in Fig. 3. The greater shaphiro wilk value (<0.05) confirms the normality of data. The P-value < 0.05% confirms non-significant difference between treatment. Pearson correlation matrix (>0.95) between growth parameters of poplar (dbh, basal girth and height) showed strong positive correlation. In fruit crops, the vegetative growth parameters such as stock girth, scion girth and height of the plants were recorded for both inter-cultivated as well as control plants. Among the fruit crops, highest stock

girth was recorded in peach (20.53 cm) followed by plum (19.82 cm), interestingly it was higher both in control as far as scion girth was concerned. Highest scion girth was recorded in peach (18.37 cm) followed by kinnow (16.14 cm) which was at par with plum (16.63 cm). Scion growth was again found on higher side (Table 1) Maximum height was observed in guava (2.967 cm) which was at par with peach control (2.958 cm).

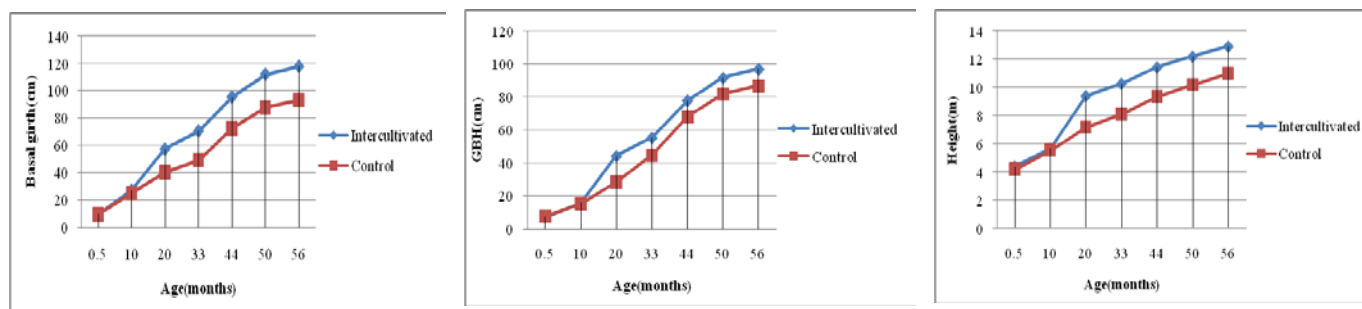
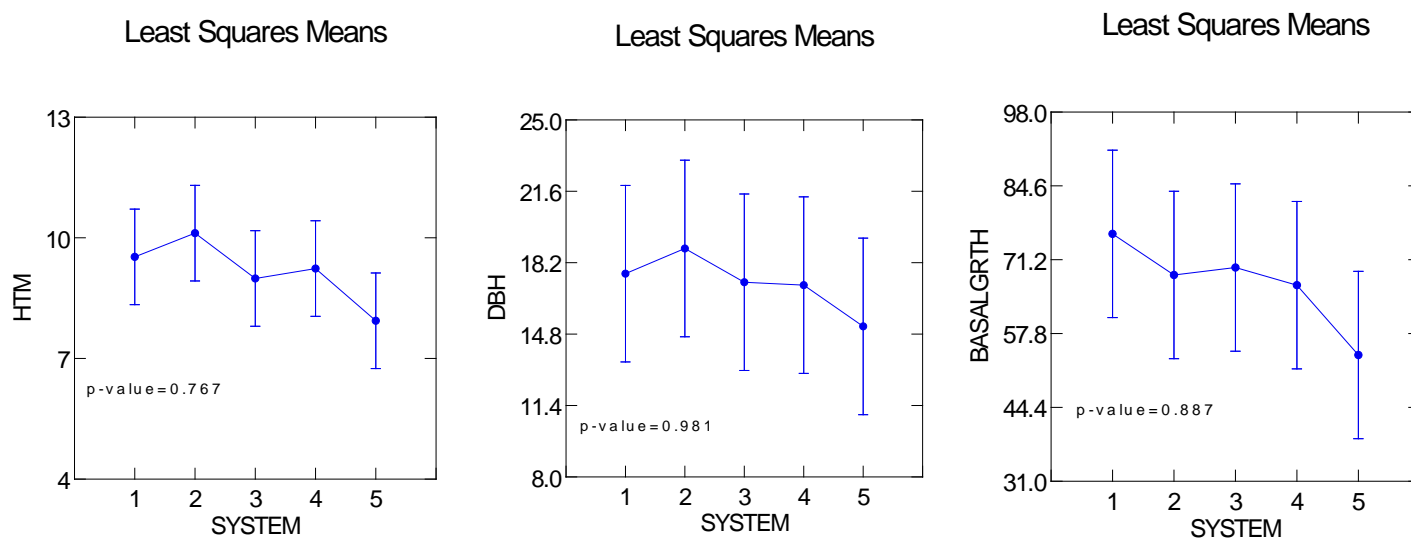


Figure 2. Comparison of growth attributes of poplar in inter- cropping (irrespective of fruit plants) and control



1: Kinnow+poplar; 2: Guava+poplar ; 3: Peach+poplar; 4: Plum+poplar; 5: Control

Figure 3. Growth variables of poplar inter-planted with different fruit crops and control

Table 1. Descriptive statistics of vegetative growth parameters of different fruit crops inter- planted with poplar (56 months after planting)

Fruit trees	treatment	Parameters	Stock girth	Scion girth	height
Peach	Inter-planted	Mean	17.478 (1.10-31.19)	15.298 (0.89-27.71)	2.477 (1.10-4.27)
		SD	10.893	9.566	1.158
	Control	Mean	20.535 (1.01-35.96)	18.377 (0.84-32.37)	2.958 (1.08-4.09)
		SD	13.255	12.055	1.064
Plum	Inter-planted	Mean	15.843 (1.12-26.34)	13.435 (0.91-22.74)	2.185 (1.04-3.36)
		SD	9.198	7.900	0.847
	Control	Mean	19.828 (1.17-33.65)	16.635 (0.85-26.15)	2.343 (1.07-3.65)
		SD	11.706	9.384	0.992
Kinnow	Inter-planted	Mean	15.435 (0.65-25.47)	13.902 (0.35-24.78)	2.010 (0.38-3.32)
		SD	9.049	8.913	1.080
	Control	Mean	17.598 (0.65-30.14)	16.140 (0.28-29.79)	1.937 (0.33-3.54)
		SD	10.559	10.861	1.160
Guava	Inter-planted	Mean	18.437 (1.35-27.73)	16.648 (1.21-25.22)	2.967 (0.67-4.37)
		SD	9.449	8.560	1.316
	Control	Mean	18.688 (1.43-32.29)	16.155 (1.05-27.27)	2.155 (0.48-3.62)
		SD	11.036	9.446	1.111

3.2. Organic matter/nutrient addition in the poplar based horti- silvicultural system

Poplar sheds its leaves from late September to January and leaves fallen in the months of September and early October are incorporated in the soil during field operations. The litter falling during November to January also gets incorporated into the soil as a result of various cultural practices (e.g. hoeing, irrigation, etc.) given to crops, whereas the remains of litter-fall are incorporated into the soil at the time of sowing of succeeding crops. It is evident from Fig 4 that leaf shedding started earlier in 2nd week of November. Maximum leaf fall occurred during January in both four and five year old poplar. Poplar trees were totally leafless during February. The new leaves emerged during first fortnight of March. Fig. 5 and Fig. 6 shows year- wise and month-wise nutrient availability, respectively due to decomposition of tree leaves. The maximum availability of phosphorus and phosphorus was under 4 year canopy, whereas, in case of nitrogen, it was highest in 5 year old poplar canopy. Further, there were significant differences between nutrient availability in different months of the year, a higher increase during April to October may be attributed to release of these nutrients from decomposition of litter-fall and organic nutrient reserves because of high temperatures during summer. However, the release of nutrients from

decomposition of litter fall was less during winter because of low temperature, but increase of ambient temperature in June-August has increased their availability. Higher release of P during summer from organic reserves increased availability of P in soils has earlier been reported by Singh, Sharma and Arora[10].

It is evident from the fig. 4 that maximum nitrogen release was observed during the month of July and August (2.54 and 1.72 %) in 4th year plantation and (2.48 and 1.72 %) in 3rd year plantation. The rate of decomposition was maximum in rainy season when the moisture, temperature and soil environmental/ biological conditions were congenial. Similarly, in case of phosphorus, differences were again significant. Concentration of nutrients in different layers of soil varied considerably and it was observed in all the cases that nutrient availability decreased with depth (Fig. 7). The over whelming proportion of nutrients was found in upper layers of soil. The effects of organic matter accumulation were higher on surface than sub-surface horizons and trees increased or at least maintain the organic matter status of soils. The application of recommended chemical fertilizers in fruit crops seems to have maintained the nutrient level with the increasing age of the plantations, even though the nutrient uptake by the poplar trees had increased with the age. Maximum values for N, P and K was observed under 4 year old plantation except organic carbon which was

observed maximum under 5 year old plantation due to reason that more organic matter decayed with increase in canopy age and crops grown under trees. Additional application of fertilizer is essential to maintain the soil fertility and productivity of the system. Durai, Ralhan, Sharma, Singh and Chauhan[11] emphasized that the deliberately planted trees for enhanced economic gains will certainly exploit the natural resources including inherent nutrients. As far as different trials were considered, available phosphorus and nitrogen was found on higher side in filler experiment, which was at par with control plots, except potassium and carbon, which was found on higher side in control plots. On account of recycling of organic matter, higher organic carbon (OC) and available N, P and K content were observed by Sharma, Singh & Dhadwal[12] and Singh & Sharma[13] in the soil under an inter-cropped

poplar plantation than at a site without poplar trees. However, Singh, Chauhan, Rajput and Singh[14] recorded varied contents on the basis of intercrops. Total litter production in poplar plantations increased significantly with tree age, resulting in elevated soil OC status was reported by Mohsin, Singh and Singh[4] and Singh, Gill and Kaur[15], however, the intervention need to be continued to maintain the higher OC status otherwise it would revert back to its original state. Nair, Nair, Mohan Kumar and Showalter[16] reported that the soil organic matter represents a significant carbon store and can remain in the soil for extended periods as a part of soil aggregates. The fraction of soil organic matter that is so protected from further rapid decomposition is very important from the point of view of soil carbon sequestration.

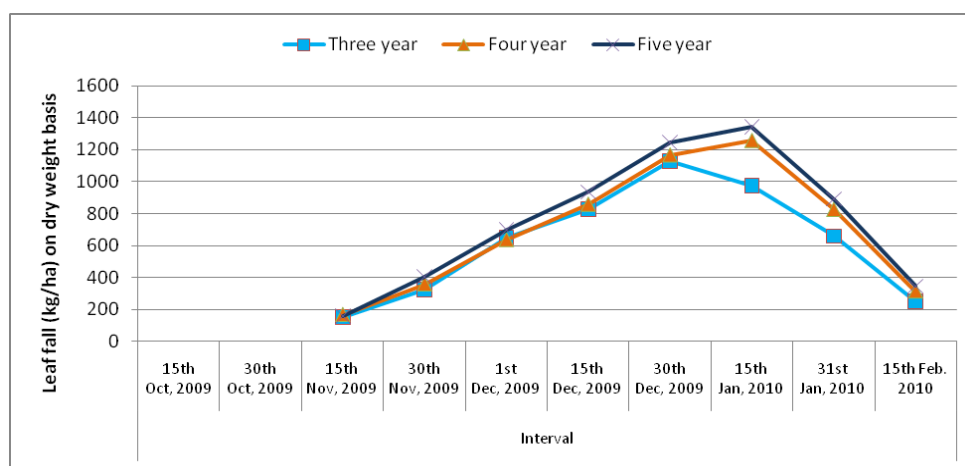


Figure 4. Fortnightly variation in the dry weight of the fallen leaves in three, four and five year old poplars

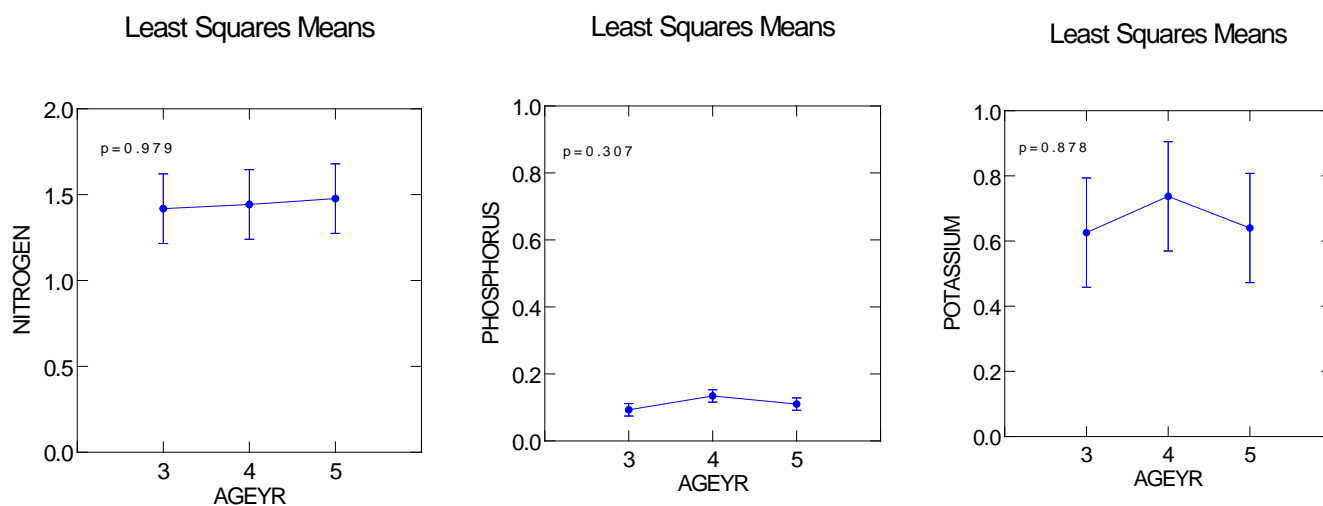
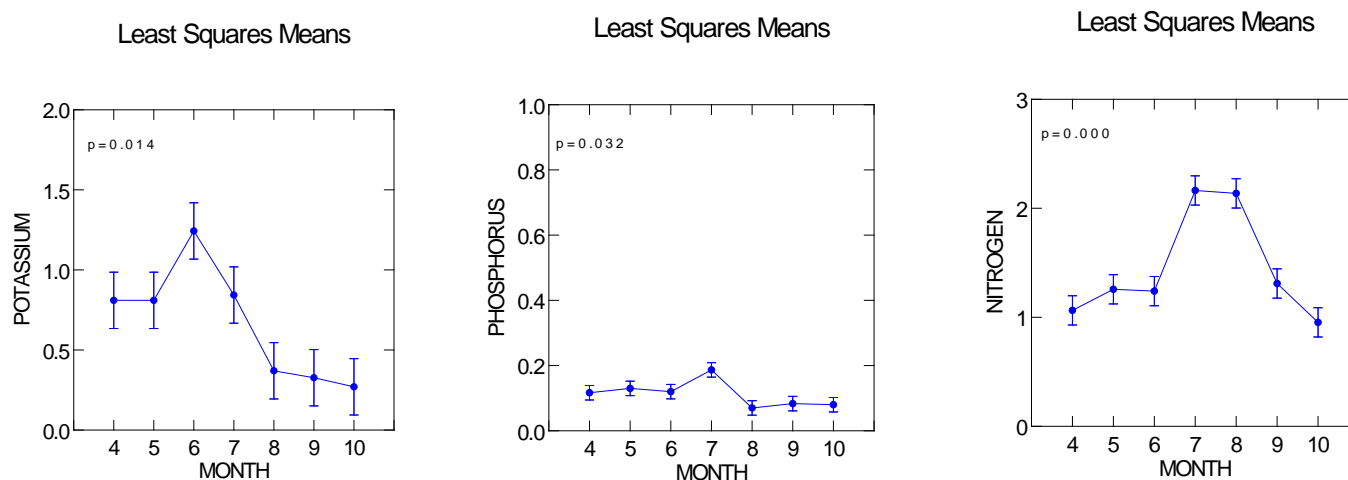


Figure 5. Year-wise availability of nutrient due to decomposition of poplar leaves



4: April; 5: May; 6: June; 7: July; 8: August; 9: September; 10: October

Figure 6. Month-wise availability of nutrient due to decomposition of poplar leaves

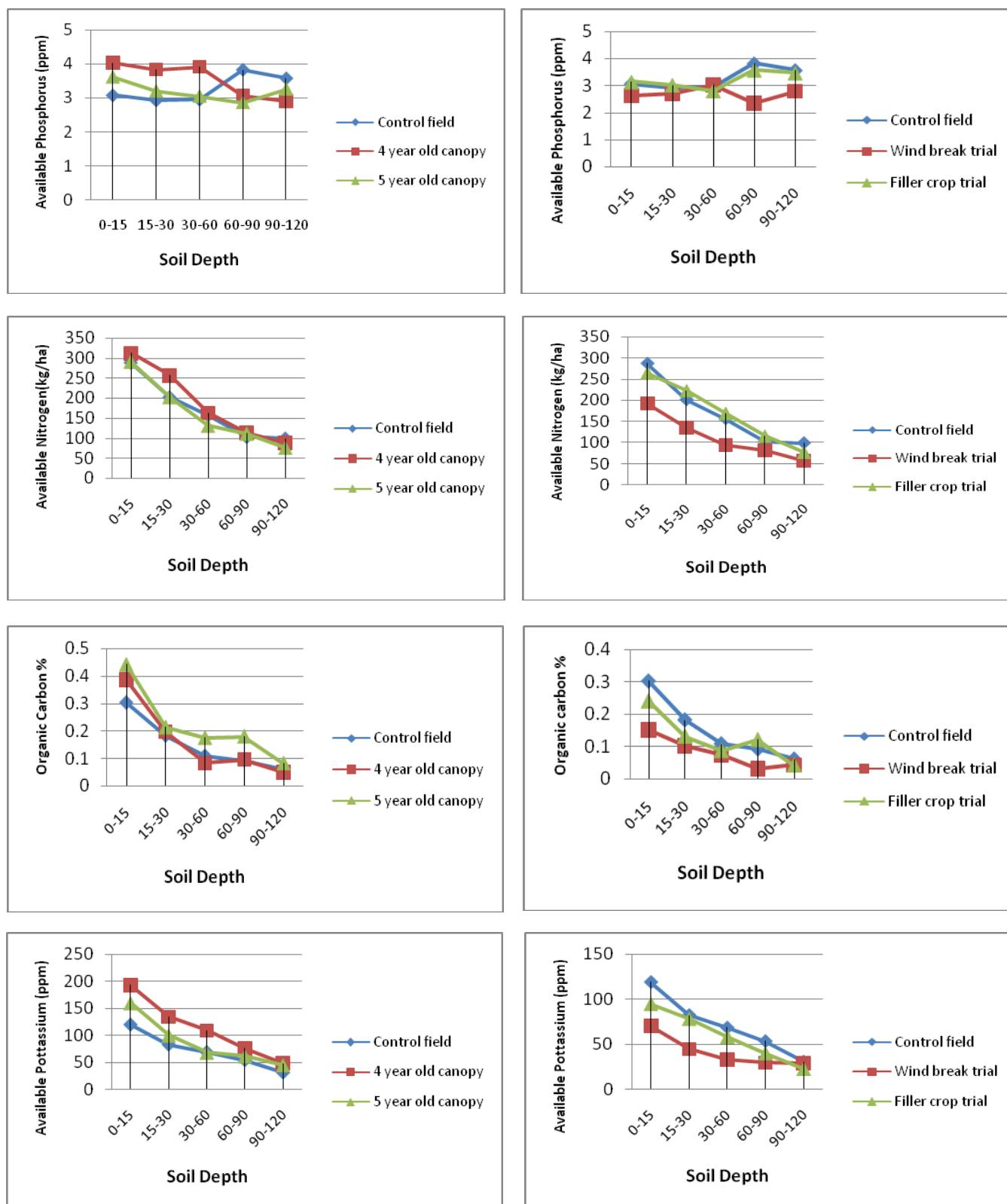


Figure 7. Availability of various nutrients in different trials at different depths of the soil

4. CONCLUSION

There exists a great scope to take up horti-silvicultural systems by compatible eco-friendly combinations of poplar and horticultural crop components. Poplar grows better in inter-cropping due to utilization of nutrients and irrigation applied regularly to fruit trees than pure poplar plantations. Besides, poplar with fruit trees is characterized by higher rates of nutrient accumulation in the soil through litter fall thus further enriches the soil which is beneficial to the fruit trees and build-up of organic carbon in depleting soils under intensive cultivation in irrigated agro-ecosystems.

5. ACKNOWLEDGEMENT

Authors are thankful to Indian Council of Agricultural Research, New Delhi (India) for financial support to conduct the present investigations.

REFERENCES

- [1] J.P. Chandra, Ind. J. Ecology 38, 11-14 (2011).
- [2] D. C. Karnatak, Indian Forester 122, 137-143 (1996).
- [3] B. Bernier, IEA/ ENFOR joint report. Canadian Forestry Service, Department of Environment, Ottawa, Ontario, Canada, p. 46, (1984).
- [4] F. Mohsin, R. P. Singh and K. Singh, Annuals of Forestry 7, 254-262 (1999).
- [5] S. C. Allen, S. Jose, P.K.R. Nair, B.J. Brecke, P. Nkedi-Kizza and C.L. Ramsey, Forest Ecology and Management 192, 395-407 (2004).
- [6] D. N. Mugendi and P. K. R. Nair, Agroforestry Systems 35,187-201 (1997).
- [7] L. Wilkinson and M. Coward, Systat: Statistics-II. (Version 11). Systat software Inc, Sanjose, CA-95110, (2007).
- [8] G. Singh, N.T. Singh, J.C. Dagar, H. Singh and V.P. Sharma, Agroforestry Systems 37, 279-295 (1997).
- [9] S.K. Chauhan and P.S. Mangat, Asia-Pacific Agroforestry Newsletter 28, 7-8 (2006).
- [10] H. Singh, K. Sharma and N. B. S. Arora, Fertility Research 40, 7-19 (1995).
- [11] M.N. Durai, P.K. Ralhan, R. Sharma, A. Singh and S. Chauhan, Indian Forester 135, 1716-1723 (2009).
- [12] N.K. Sharma, H.P. Singh and K.S. Dhadwal, Ind. J. Soil Conserv. 28, 221-225 (2000).
- [13] B. Singh and K.N. Sharma, Agroforestry Systems 70, 125-134 (2007).
- [14] K. Singh, H. S. Chauhan, D. K. Rajput and D.V. Singh, Agroforestry Systems 9, 37-45 (1989).
- [15] B. Singh, R. Gill and N. Kaur, Ind. J. Agroforestry 9,33-37 (2007).
- [16] P.K.R. Nair, V.D. Nair, B. Mohan Kumar and J.M. Showalter, Advances in Agronomy 108, 237-307 (2010).